3-D

High Resolution

Short Offset

PROCESSING

Garden Banks IIB and Mississippi Canyon I

for

U.S. Department of Energy/ Texas A&M University

July 2001

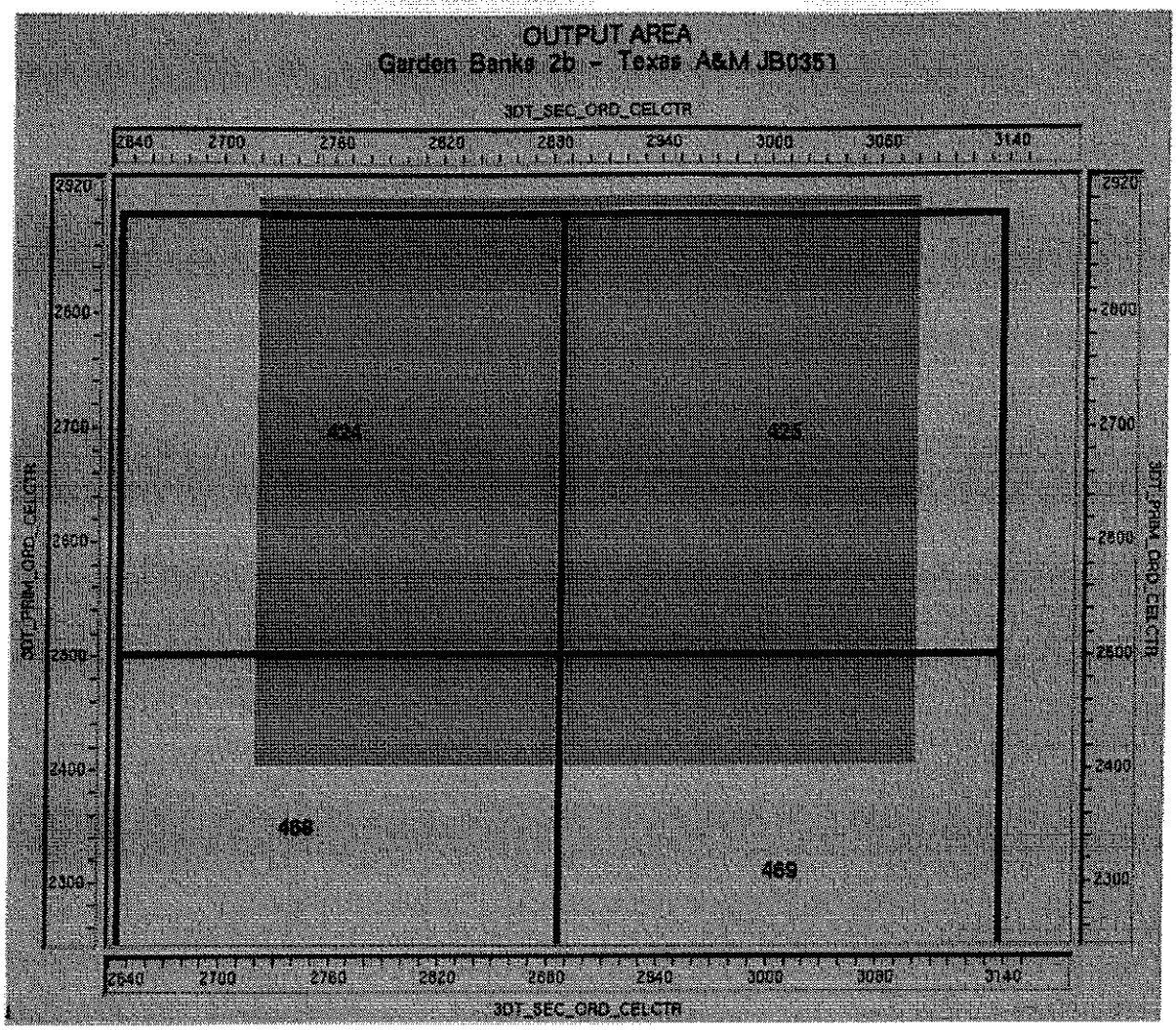
Index

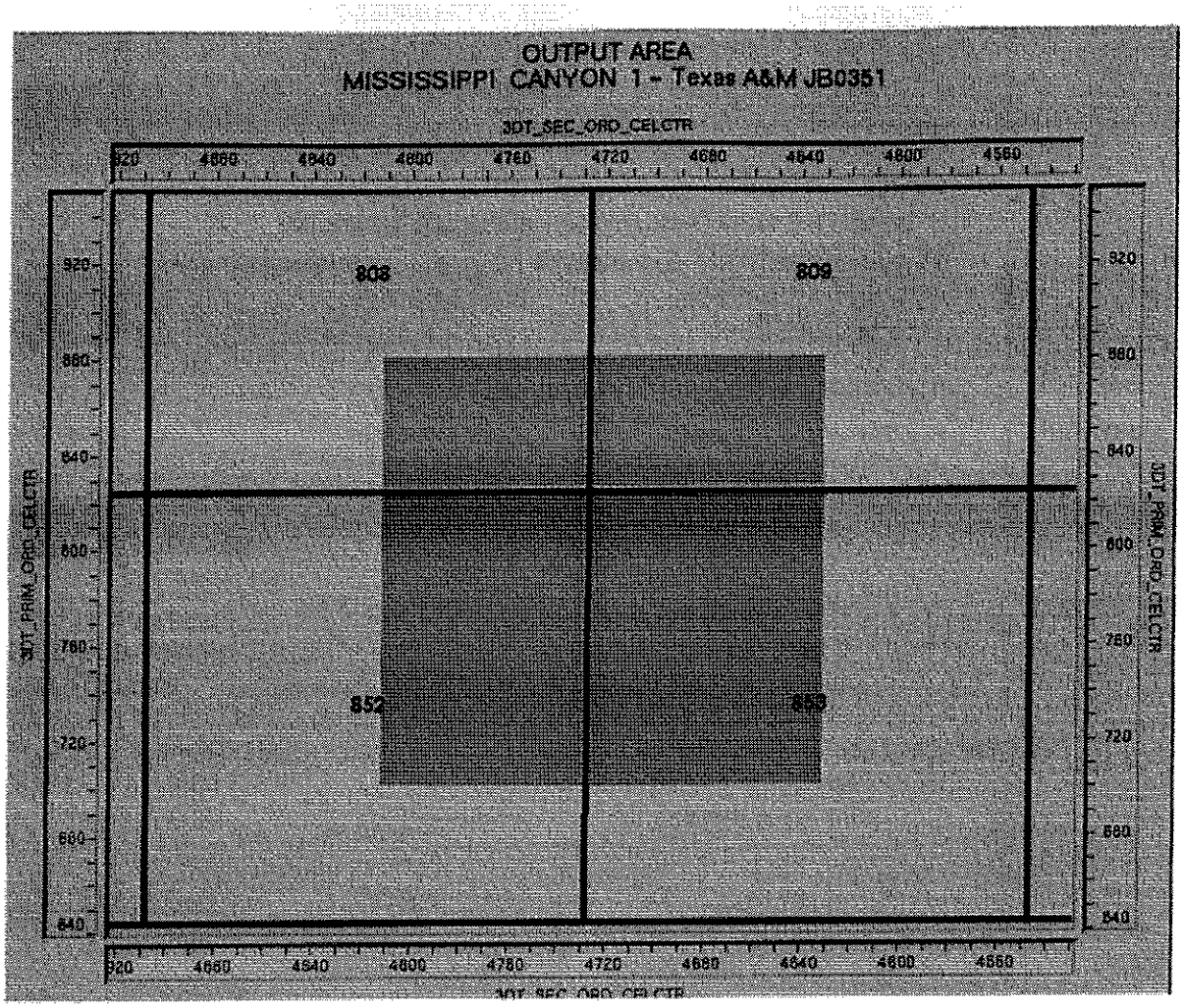
INTRODUCTION

In April of 2001 WesternGeco's Houston Marine Processing Center was asked to reprocess data from a portion of a 3-D Multi-Client survey covering 2 OCS blocks from Mississippi Canyon 1 (Blocks 424 and 425) and Garden Banks IIB (Blocks 852 and 853) surveys located in the Gulf of Mexico.

The High-Resolution Processing team began the processing of Garden Banks IIB and Mississippi Canyon I on April 19, 2001 and ended on July 24, 2001. These surveys contained data from WesternGeco's 3-D Mississippi Canyon Phase 1 and Garden Banks Phase IIA Multi-Client survey consisting of an estimated (input) area to process of 2.0 OCS blocks or 9 square miles from each survey.

WesternGeco worked closely with Rita Hearn from the U.S. Department of Energy and William Sager from Texas A&M University on all aspects of processing for this project.


OUTPUT AREA
Garden Banks 2b - Texas A&M JB0351
3DT_SEC_GRD_CELCTR
2640
2700
2760
2820
2880
2940
3000
3060
3140
3DT_PRIM_GRD_CELCTR
2920
2800
2700
2600
2500
2400
2300
424
425
468
469


OUTPUT AREA
MISSISSIPPI CANYON 1 - Texas A&M JB0351
3DT_SEC_ORD_CELCTR
4920
4880
4840
4800
4760
4720
4680
4640
4600
4560
808
809
852
859
3DT_PRIM_ORD_CELCTR
920
880
840
800
760
720
680
640

ACQUISITION PARAMETERS

Western Geophysical Multi-Client 3-D data
Mississippi Canyon Phase 1 & Garden Banks 2B

DUAL SOURCE:

Type of Source	:	Airguns (dual)
Total Gun Volume	:	5400 cubic inches per source
Gun Pressure	:	1800 psi
Shotpoint Interval MSCN1	:	40 meters / 131.2 feet (alternating)
Shotpoint Interval GB2B	:	53.3 meters / 175 feet (alternating)
Gun Depth MSCN1	:	7.6 meters ± 1 meter
Gun Depth GB2B	:	10.7 meters ± 1 meter

INSTRUMENTS:

Type of Instruments	:	LRS-16A
Sampling Interval	:	2 ms
Field Format	:	SEG-D Demultiplexed
Filter	:	Lo cut 6 Hz, 24 dB/oct Hi cut 128 Hz, 120 dB/oct
Record Length MSCN1	:	10.0 sec
Record Length GB2B	:	9.0 sec

DUAL CABLE:

Type of Cable	:	Streamers (2)
Cable Length MSCN1 Length GB2B	:	4800 meters /15744 feet per cable
Cable	:	5100 meters /16728 feet per cable
Cable Depth	:	10 meters ± 1.5 meter
Receiver Interval MSCN1	:	26.67 meters / 87.5 feet
Receiver Interval GB2B	:	25.00 meters / 82.0 feet
Nominal Fold MSCN1	:	30 fold lines
Nominal Fold GB2B	:	51 fold lines
Number of Groups MSCN1	:	180 per cable
Number of Groups GB2B	:	204 per cable

Personnel, Software, and Processing Equipment

WesternGeco Personnel Involved

Michael Sebzda	Manager
Bob Vauthrin	Area Geophysicist
Larry Cain	Assistant Manager
Randy Hebert	Supervisor
Tom Dittrich	Team Leader
Andrew Bishop	Processing Geophysicist I

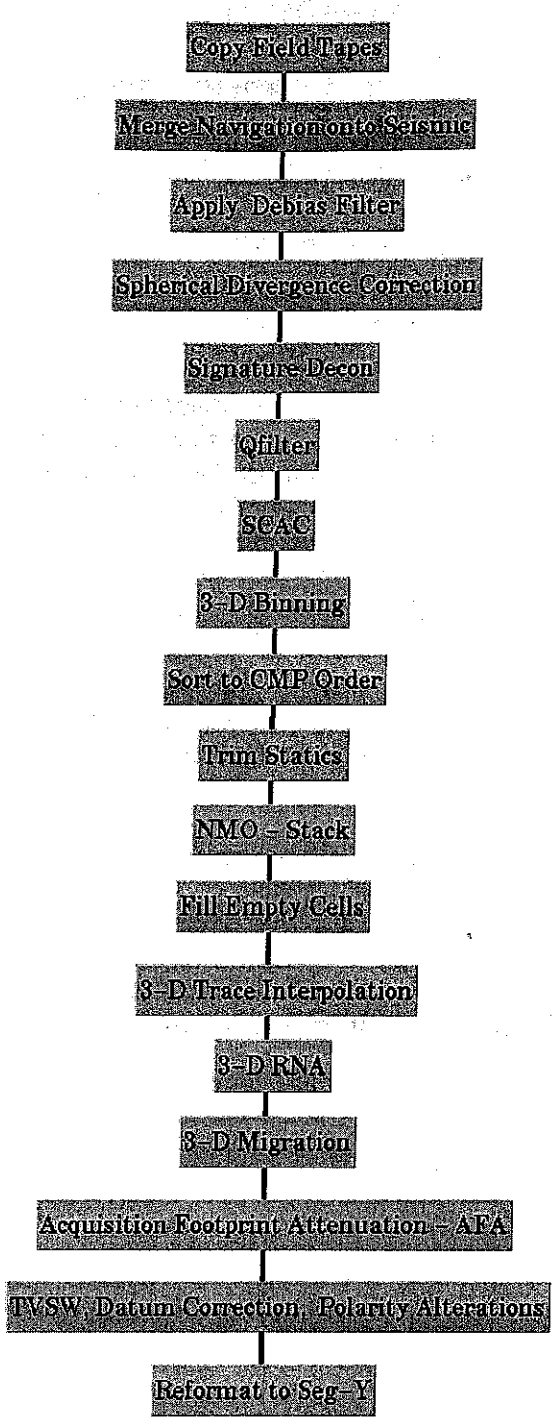
Software

Omega® Seismic Processing Software Version 1.8.1

Equipment

IBM® RS/6000® SP2
IBM® AIX® version 4.3.3

GARDEN BANKS 2B & MISSISSIPPI CANYON 1 PROCESSING FLOW



Processing Sequence

1) **Demultiplexed In The Field**
Recorded at 2 ms sampling interval.

2) **Convert data and Select Off Area to Process**
The Seg-D data was converted to WesternGeco's structured format and a trace selection was made to pull off enough traces (~50) from each cable to make the final fold per cell at least 9 traces. A 2ms sampling interval is maintained. Quality control procedures included, displaying selected shot records from each shot line, Single near trace display for each shot line. These displays are used in detecting noisy shots, recording problems, or other seismic interference.

3) **Merge Processed Navigation with Seismic Data**
The navigation headers were merged onto the seismic data and gridded to the natural acquisition grid.

CMP Cell Size: MSCN 1 - Inline 53.3 m, Crossline 13.3 m
GB2B - Inline 40.0 m, Crossline 12.5 m

Figure 1. On the following page shows an example of a single shot (with both sources plotted) with navigation applied. These are one of the methods of quality control we use to find navigation or seismic problems.

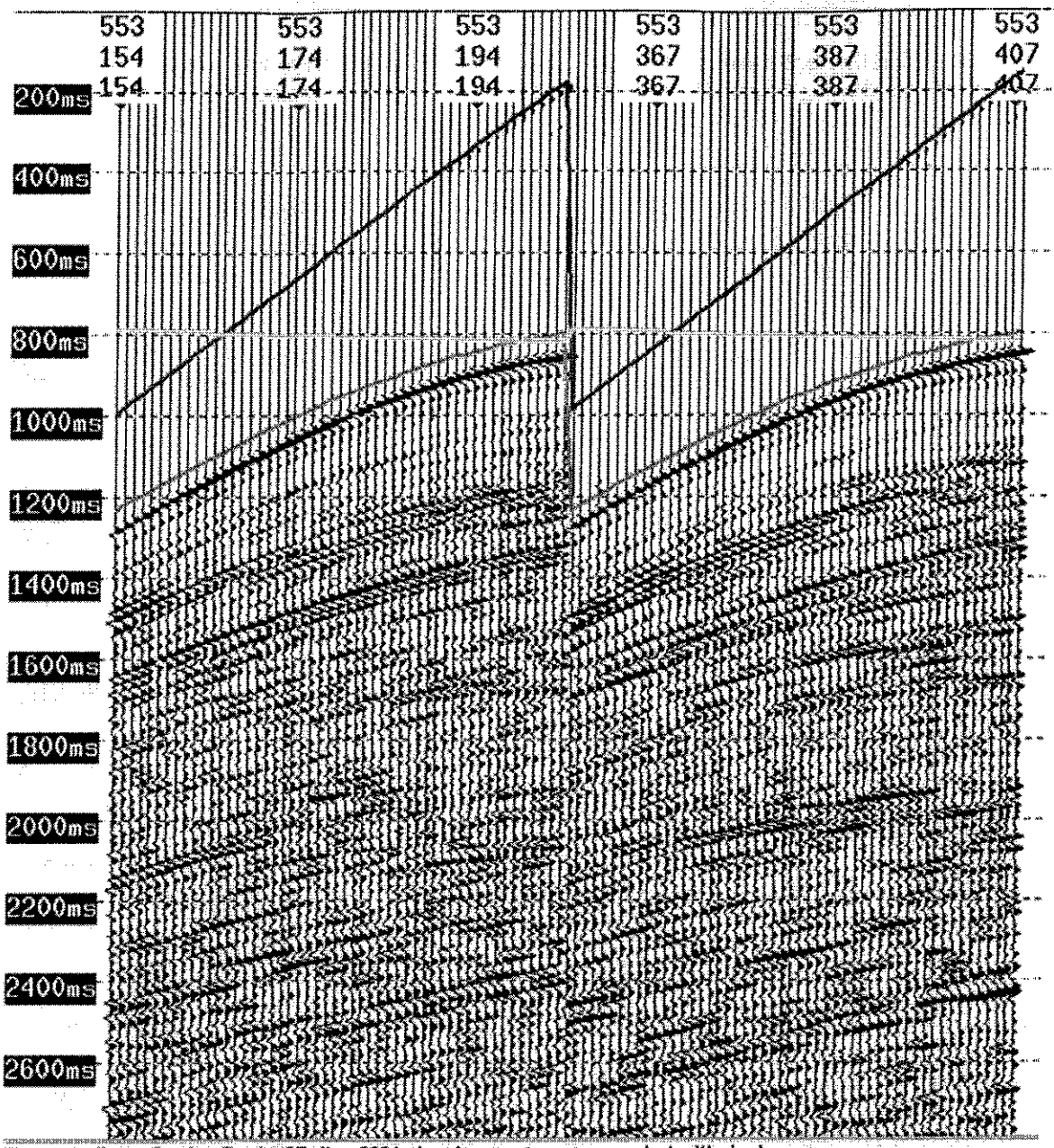


Figure 1. From Garden Banks 2B, line 2891 showing post navmerge shot with dual sources.

4) Debais Filter

A debias filter is applied in order to remove very low-frequency bias from the data.

5) Spherical Divergence Correction

Spherical Divergence Correction, a time-variant gain, compensates for the gradual decay in amplitudes with time caused by geometric spreading from the source.

The Spherical Divergence Correction can be shown in equation form as:

$$G(t) = [\, V^2 T \,] / [\, V_w^2 T_1 \,],$$

where V = rms (root mean square) velocity
T = two-way travel time
V_w = initial velocity
T_1 = 1 second

6) Signature Deconvolution

Application of the source and instrument designature operator (zero phase).

7) Q filter

A phase only constant (150) inverse Q was applied from the water-bottom. Figure 2., below shows the same shot from Figure 1., with steps 4-7 above applied

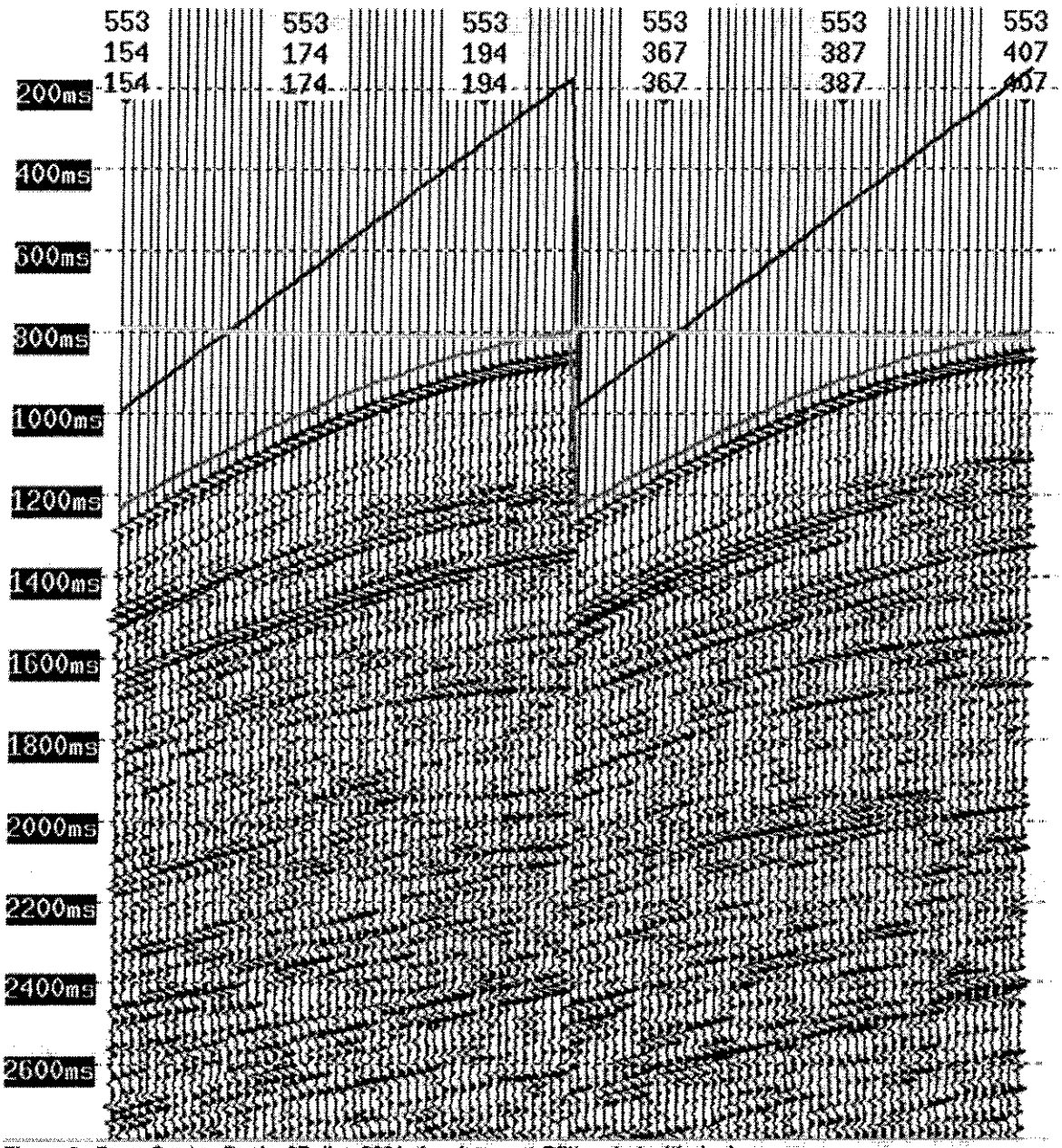


Figure 2. From Garden Banks 2B, line 2891 showing post Qfilter shot with dual sources.

8) Surface Consistent Amplitude Compensation (SCAC)

Due to source related amplitude inconsistencies within the data, SCAC was applied by picking and decomposing the geology, source, receiver and offset terms, then applying the source term only.

9) 3-D Binning

The same bin sizes and offset ranges were used as was used in the original Spec survey, as these parameters fully optimize the shooting pattern. A 3-D Flexi-

binning table was used to remove redundant offsets; no flexing of traces was done, the flex table was built with 9 traces per cell.

Primary (acquired) Cell Size: MSCN1 - 53.3m inline X 13.3m crossline
GB2B - 40.0m inline X 12.5m crossline

Offset segmentation:

offset #	offset range
01	0 – 310m
02	311 – 462m
03	463 – 618m
04	619 – 775m
05	776 – 934m
06	935 – 1093m
07	1094 – 1252m
08	1253 – 1411m
09	1412 – 1571m

10) Sort to CDP

Data sorted by CDP numbers as a primary and OFFSET numbers as the secondary.

11) Trim statics application

In order to remove any static shifts inherent in the data due to water velocity fluctuations, a trim static value for each trace was computed within each cdp, windowed near the water-bottom, using a 6 fold brute stack volume as a model. Typically these values were no more than +or- 2ms.

12) Populate CDP

In order to help balance the fold where necessary, the traces within each cdp (9 max) were renumbered, the first 6 traces were then selected within each cdp thereby allowing up to 3 additional traces from adjacent offsets to be included within a cdp when lacking 6 traces.

13) NMO / Stack

NMO was applied to the cdp's with the velocities from the original survey processing. The cdp's were stacked.

Figure 3 on the following page is an example of a CDP stack from Garden Banks 2B Crossline 2720. Figure 4 and 5 will show the continuous processing from interpolation then migration.

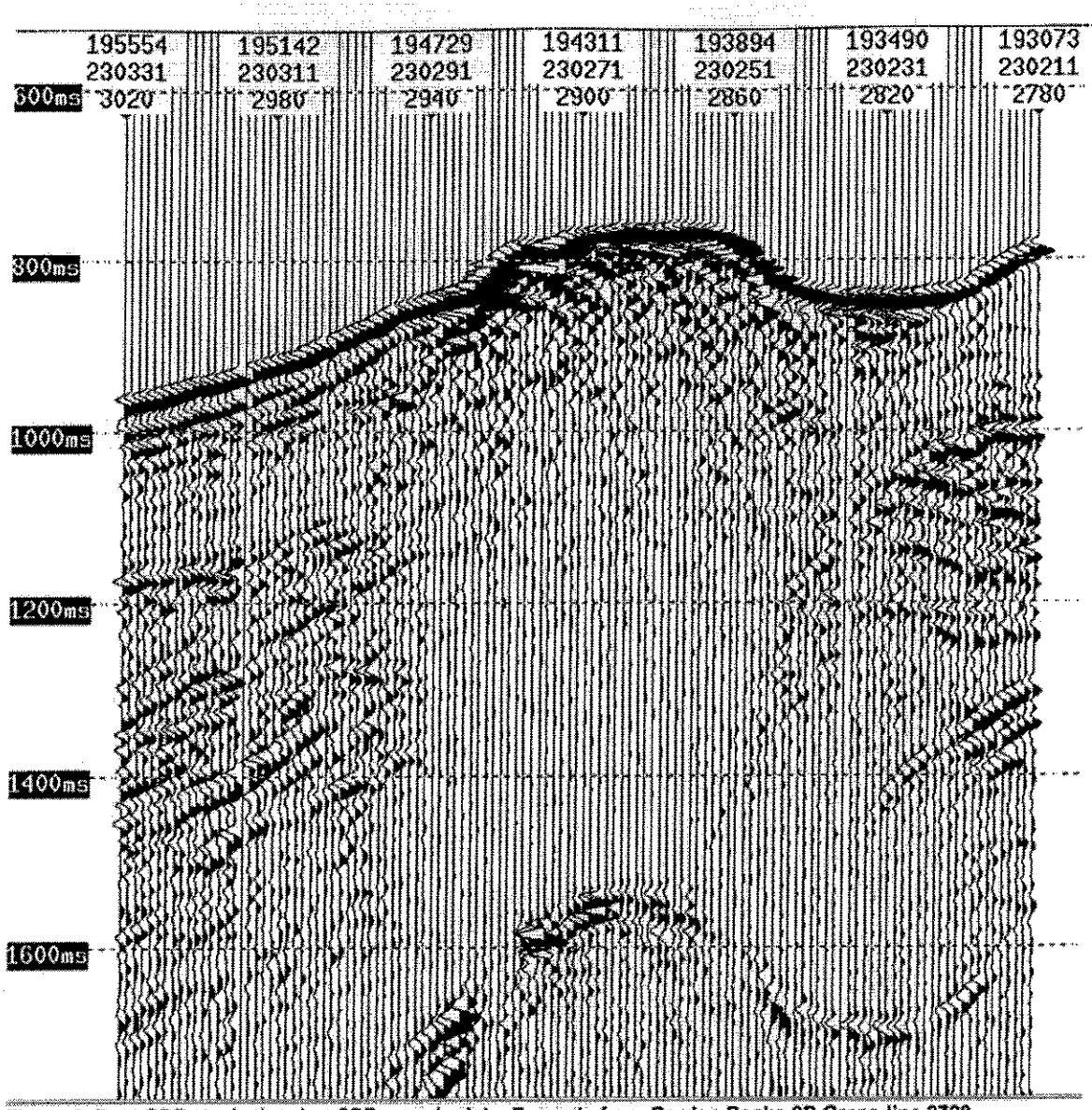


Figure 3. Post CDP stack showing CDP gaps in data. Example from Garden Banks 2B Cross-line 2720.

14) Sort to crossline order

In order to prepare the data for a crossline interpolation the data was sorted to crossline order.

15) 2D crossline interpolation – fill empty cells

2D interpolated data in the crossline direction in order to fill in any empty cells.

16) 3-D Trace Interpolation

The stack volume was 3-D interpolated to a new cell size:
Inline 53.3m / Crossline 13.33 m, becomes Inline 26.67 m / Crossline 13.33m for MSCN1. Inline 40.0 m / Crossline 12.50 m, becomes Inline 20 m / Crossline 12.50m. Figure 4 is an example after interpolation of new cells.

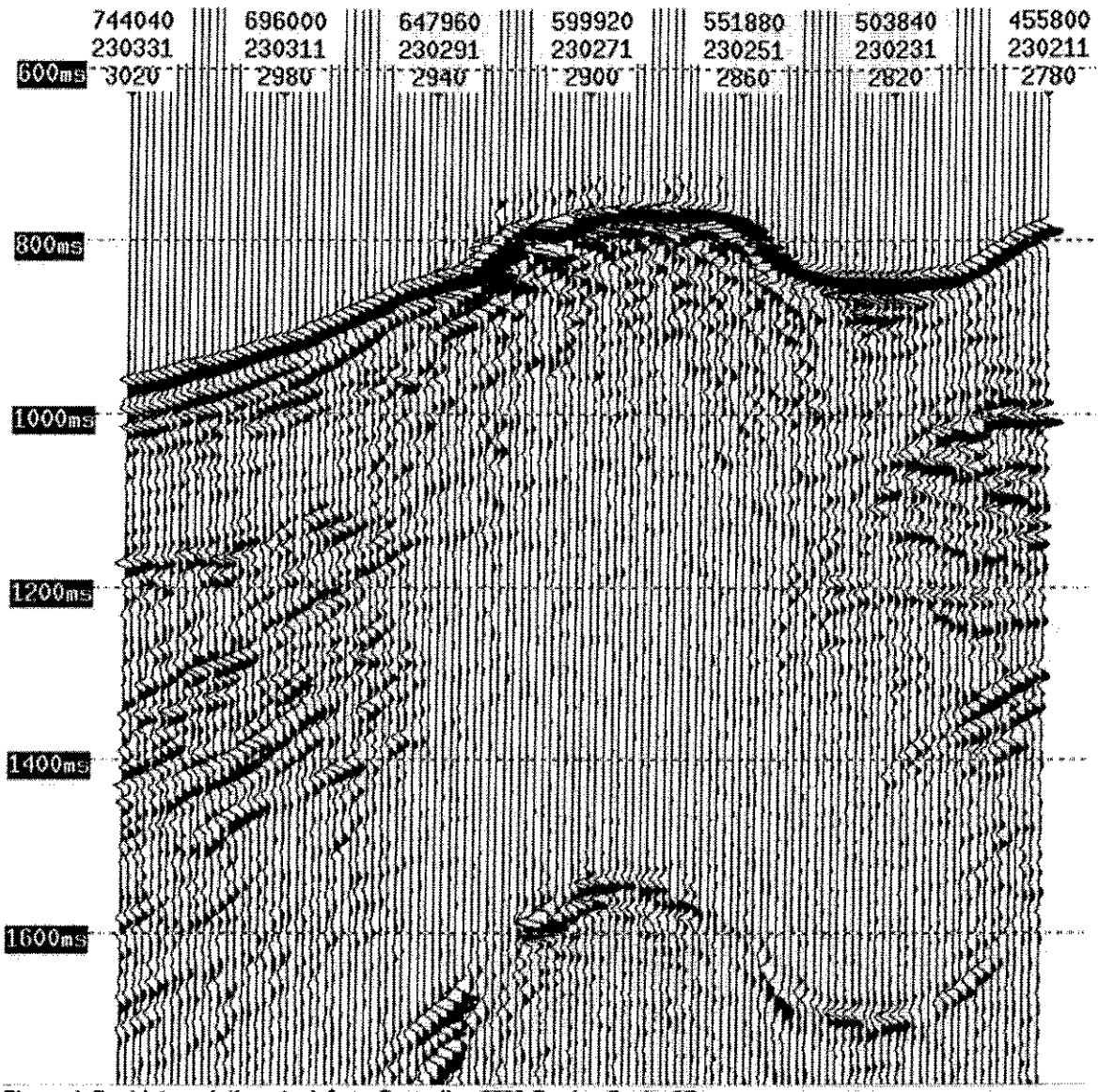


Figure 4. Post Interpolation stack from Cross line 2720 Garden Banks 2B

17) 3-D Random Noise Attenuation - RNA

The Random Noise Attenuation (RNA) process provides a method of splitting a dataset into its predictable part, which contains the signal, and its unpredictable part (random noise), which is removed. It increases continuity of geological events and attenuates non-linear noise. This process is basically an FXY decon type of approach.

18) 3-D Migration

Perform a 3-D Extended Stolt Migration using a smooth time and spatially variant velocity field. The original migration velocities were used from the vintage Spec processed survey. The data was migrated in the inline direction then sorted to the crossline direction. The trace interpolation was done in the crossline direction taking altering the inline spacing (or trace spacing).

Figure 5 shows the same cross line as figure 3 and 4 after extended Stolt Migration applied. These seismic sections show how traces are interpolated and what happens to the stack after migration.

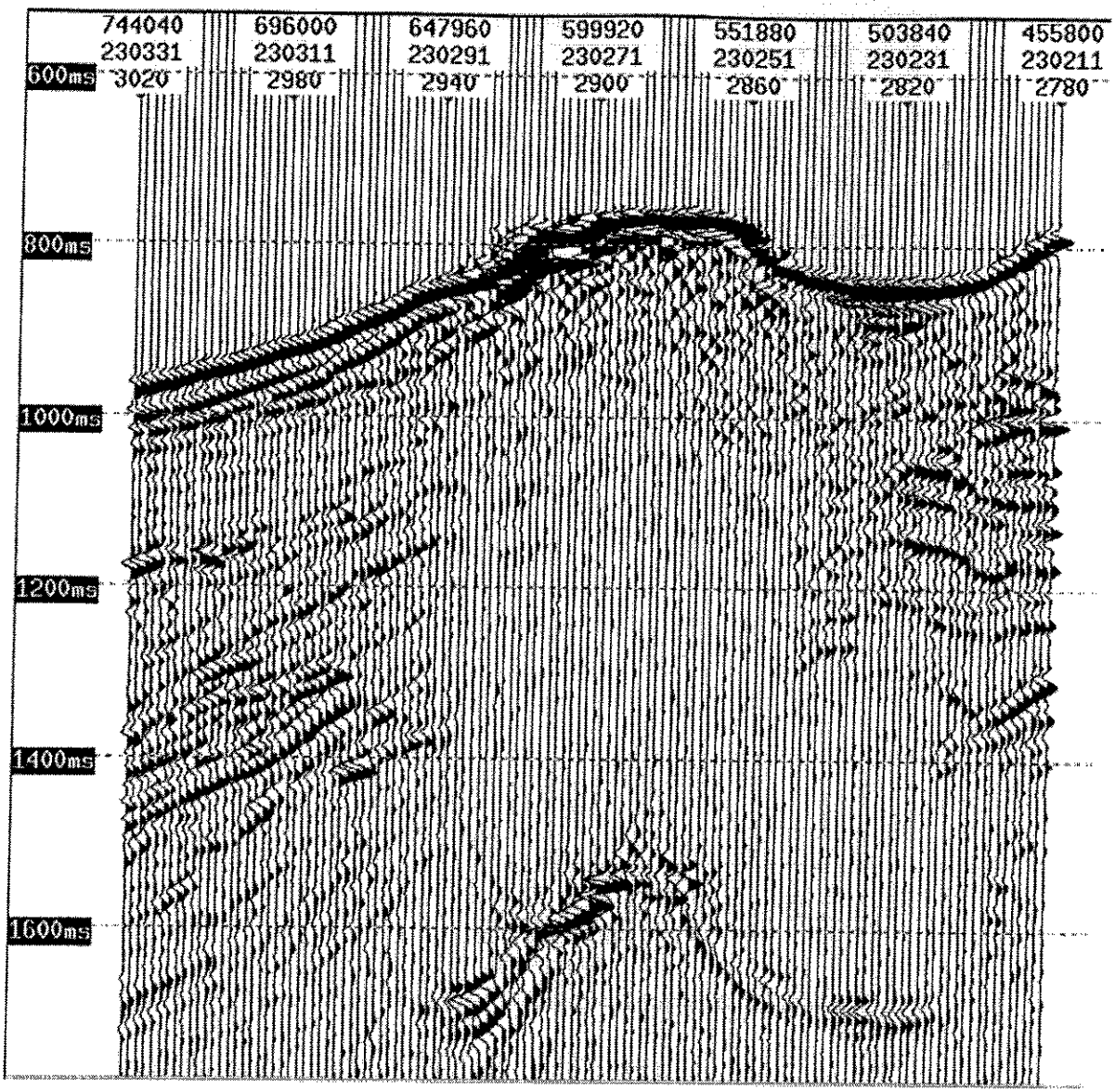


Figure 5. Example of migration stack from Garden Banks 2B crossline 2720.

19) Acquisition Footprint Attenuation (AFA)

Amplitudes were displayed at the water-bottom horizon where acquisition footprints were seen and attenuated. In this process first a 3D algorithm (RAC) was used with large spatial windows, scalars were determined that represent the average amplitudes of the cube, then trace by trace rms values were calculated representing each trace's amplitude, a trim-mean filter was applied to the rms scalars, using a 2 mile inline X 2 cells crossline filter, the resulting scalars of the trim-mean process were applied to the traces, then finally the average RAC scalars were subtracted from the trim-mean volume.

Figure 6 on the following page shows a Frequency vs. Amplitude Spectra graph after AFA is applied to MSCN1 data.

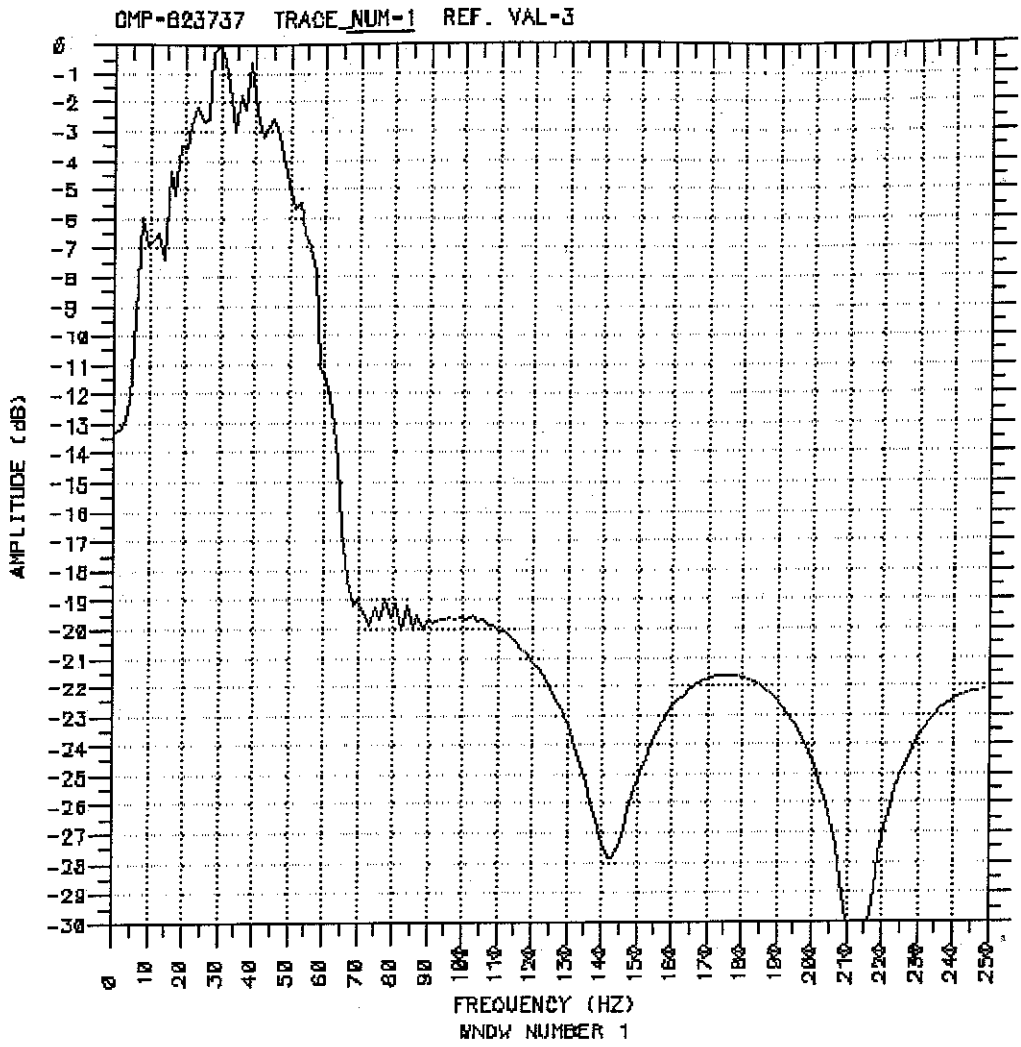


Figure 6 Mississippi Canyon 1 Frequency vs. Amplitude Spectra Graph after AFA.

20) Time-Variant Spectral Whitening (TVSW)

TVSW was necessary to apply a zero phase time variant filter to the data directly below the water-bottom to enhance the clarity of the first several events. TVSW is equivalent to frequency domain deconvolution, and used to flatten spectra without phase distortion. We used a frequency/amplitude pairings to compute the zero phase filters.

Window length 200 ms
White noise 0.1%

Figure 7 on the following page shows is another example of the Frequency vs. Amplitude spectra graph after TVSW is applied. You can see how wide the amplitude peak has increased, therefore whitening the data. This has allowed an amplitude gain to show more of the interbedded geology.

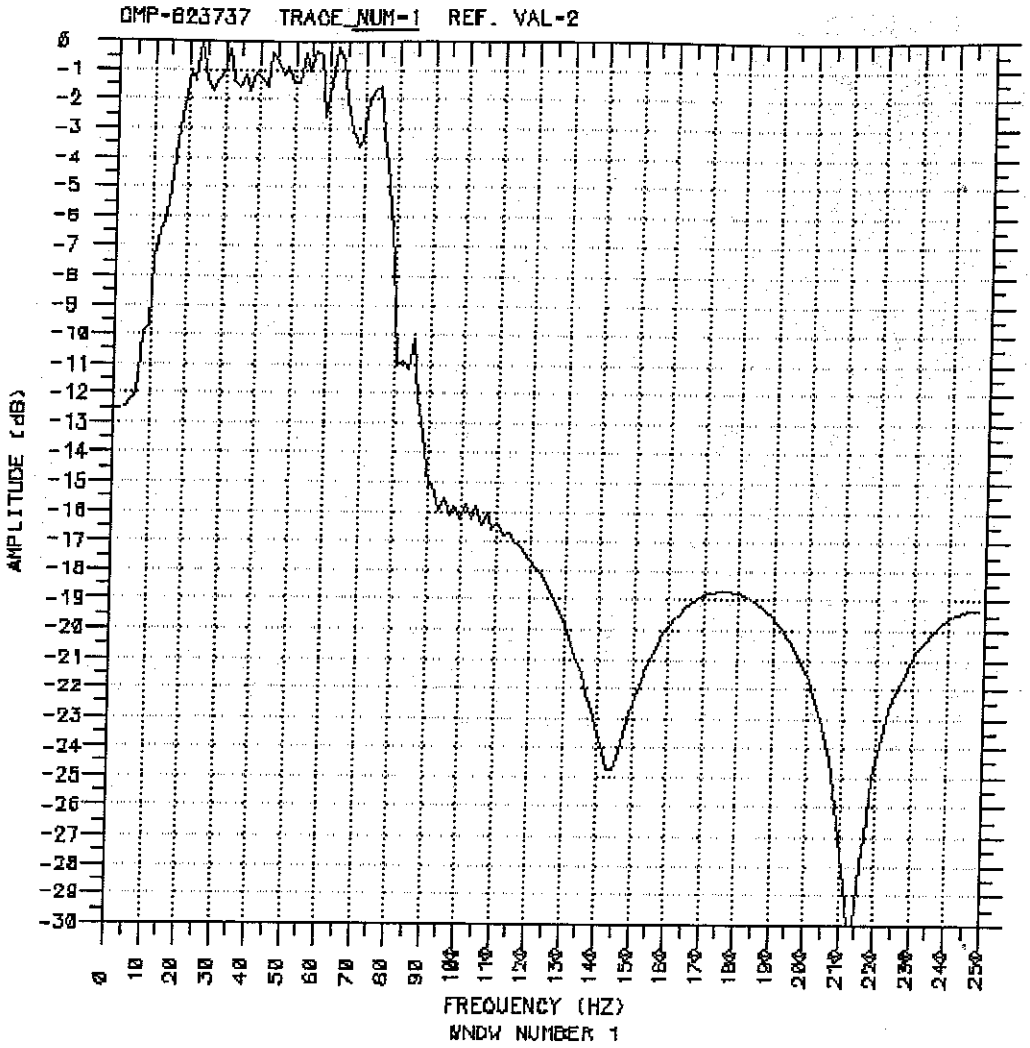


Figure 6 Mississippi Canyon 1 Frequency vs. Amplitude Spectra Graph after TVSW.

21) Final datum correction

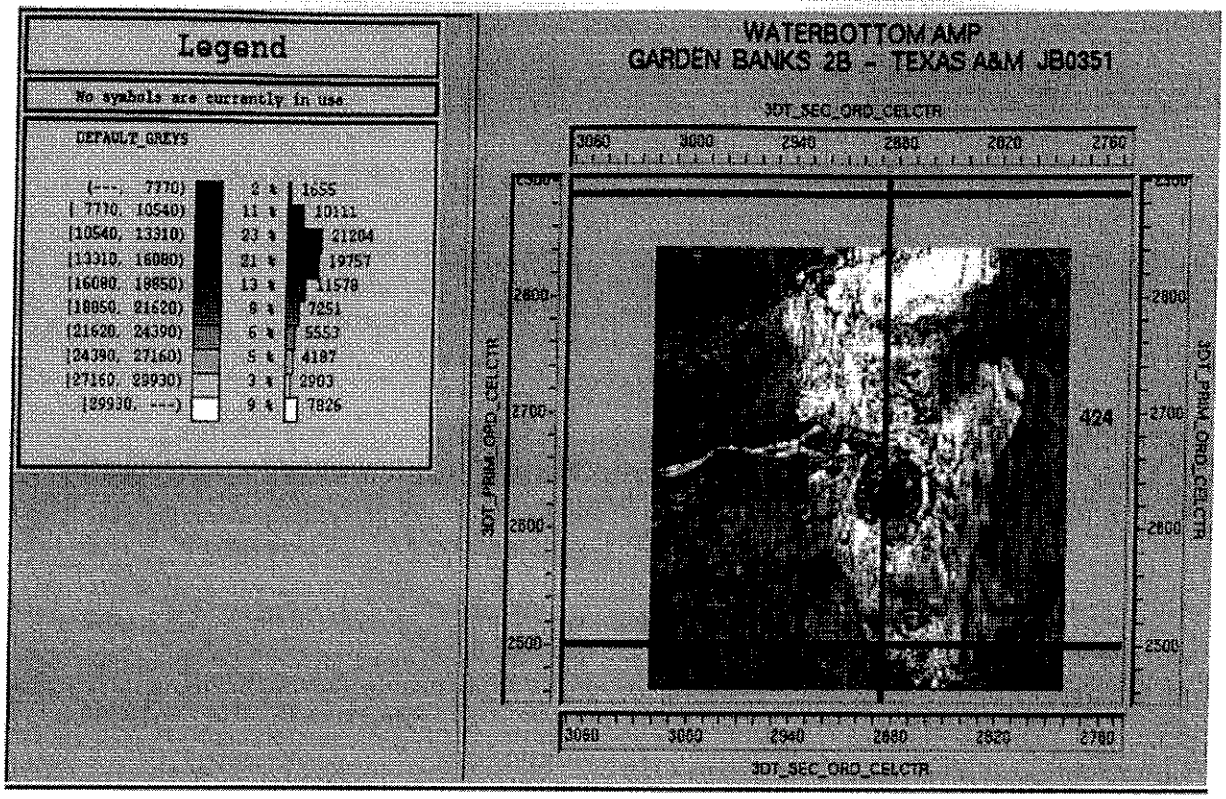
To compensate for the depths of the guns and cables the data volume was pushed down 12 ms thereby correcting the data to a sea level datum.

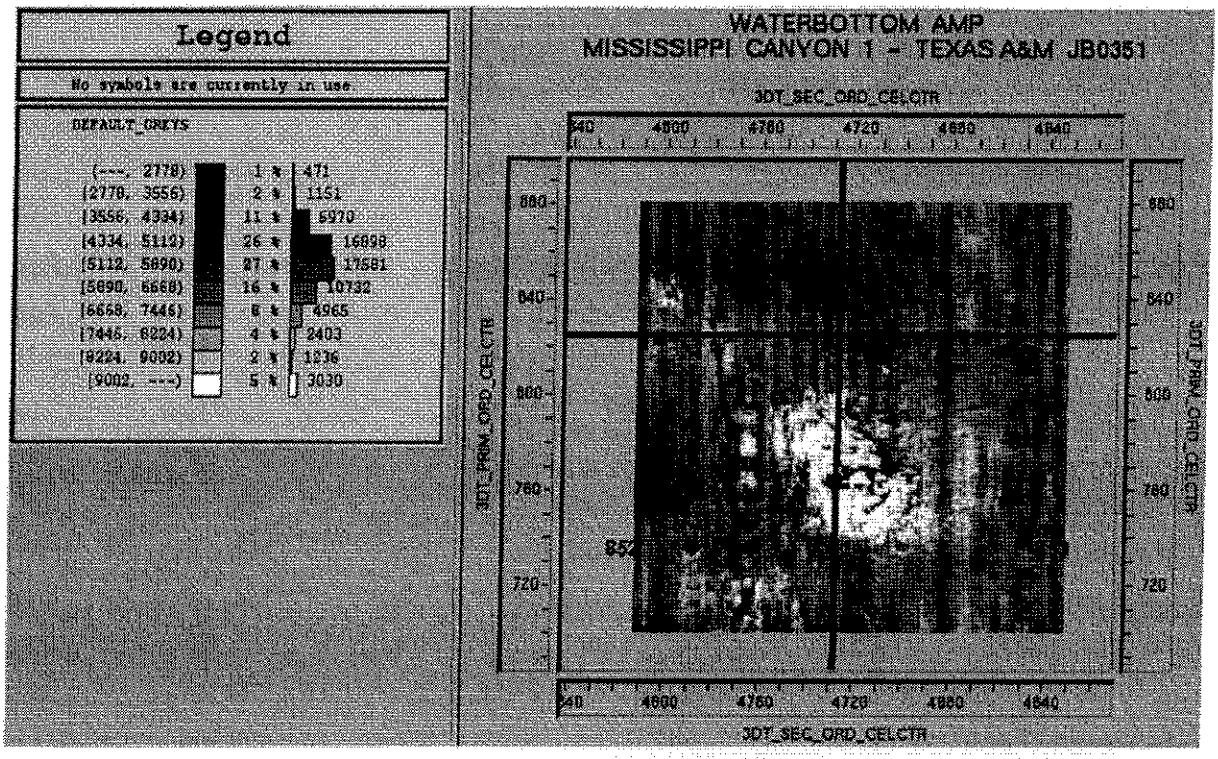
22) Final Phase Correction

Garden Banks 2B's required a 180 degree phase roll. Mississippi Canyon 1 required 120 degree roll.

23) Re-format data

Re-format data from WesternGeco format to standard Seg-Y format.


Legend
No symbols are currently in use
DEFAULT_GREYS
(---, 7770) 2 % 1655
[7770, 10540) 11 % 10111
[10540, 13310) 23 % 21204
[13310, 16080) 21 % 19757
[16080, 18850) 13 % 11578
[18850, 21620) 8 % 7251
[21620, 24390) 6 % 5553
[24390, 27160) 5 % 4187
[27160, 29930) 3 % 2903
[29930, ---) 9 % 7826
WATERBOTTOM AMP
GARDEN BANKS 2B - TEXAS A&M JB0351
3DT_SEC_ORD_CELCTR
3DT_PRM_ORD_CELCTR
424


Legend
No symbols are currently in use
DEFAULT_GREYS
(---, 2778) 1 % 471
(2778, 3556) 2 % 1151
[3556, 4334) 11 % 5970
[4334, 5112) 26 % 16898
[5112, 5890) 27 % 17581
[5890, 6668) 16 % 10732
[6668, 7446) 8 % 4965
[7446, 8224) 4 % 2403
[8224, 9002) 2 % 1236
[9002, ---) 5 % 3030
WATERBOTTOM AMP
MISSISSIPPI CANYON 1 - TEXAS A&M JB0351
3DT_SEC_ORD_CELCTR
3DT_PRM_ORD_CELCTR
852

Summary of Product Deliverables

Quantity	Product
2	8mm Stack Volume Seg-Y Tape Copy
2	8mm Migrated Stack Volume Seg-Y Tape Copy
2	8mm Bin Center Navigation Tape (P1/90 ukooa)
2	Bin Center paper maps

Tape Transmittal

Reel No.	Line	Fr Shot	To Shot	Process	Filename
101620	2400 - 3140	2100	3300	UKOOA	AT$.HA41.TAM.JB0351.GB2B.NAVP1
101082	2400 - 3140	2100	3300	MIGRATION	AT$.HA41.TAM.JB0351.GB2B.SGYMG
100730	2400 - 3140	2100	3300	STACK	AT$.HA41.TAM.JB0351.GB2B.SYSTK
100158	4631 - 4811	7000	8800	UKOOA	AT$.HA41.TAM.JB0351.MSCN1.NAVP1
103228	4631 - 4811	7000	8800	MIGRATION	AT$.HA41.TAM.JB0351.MSCN1.SGYMG
103226	4631 - 4811	7000	8800	STACK	AT$.HA41.TAM.JB0351.MSCN1.SYSTK

Seismic Data Loading Form

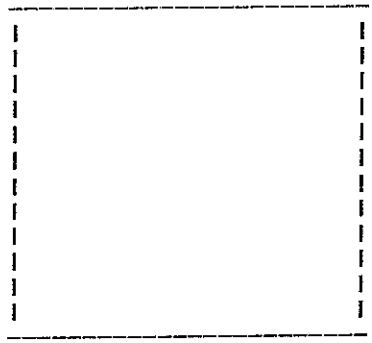
From: Western Geco
To: Texas A&M

Survey Selected: GARDEN BANKS 2B

Projection System: UTM 15

Line:	2400.00
Shot:	3300.00
X :	1758063.96
Y :	10027795.43
LONG:	-92.63652335
LAT :	27.63341974

Line:	3140.00
Shot:	3300.00
X :	1806620.17
Y :	10027795.43
LONG:	-92.48651092
LAT :	27.63294547



Line:	2400.00
Shot:	2100.00
X :	1758063.96
Y :	9978583.43
LONG:	-92.63696916
LAT :	27.49800046

Line:	3140.00
Shot:	2100.00
X :	1806620.17
Y :	9978583.43
LONG:	-92.48714070
LAT :	27.49752890

1. Only three points are needed to determine world coordinates, two on one line and any other line/trace for the third point.
2. Internal Y coordinates refer to shots.
3. Inline Spacing (Distance between Crosslines): 41.01 US_SURVEY_FEET.
4. Cross-line Spacing (Distance between Inlines): 65.62 US_SURVEY_FEET.
5. Record Length: 7000 MS.
6. Sample Rate: 2.00 MS.
7. Azimuth between the primary direction and due north: 0.00 DEGREES.

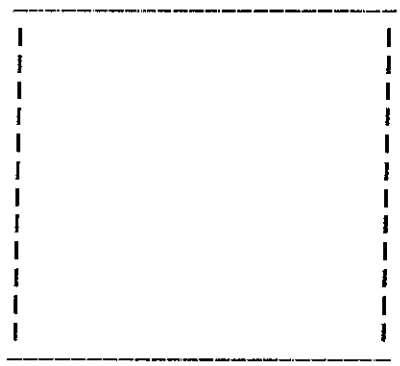
Seismic Data Loading Form

From: WesternGeco
To: Texas A&M

Survey Selected: Mississippi Canyon I

Projection System: Non Standard TM

Line:	4811.00	Line:	4631.00
Shot:	8800.00	Shot:	8800.00
X :	1560611.16	X :	1576359.17
Y :	10215476.64	Y :	10215726.94
LONG:	-89.16440335	LONG:	-89.11551904
LAT :	28.15011022	LAT :	28.15087858



Line:	4811.00	Line:	4631.00
Shot:	7000.00	Shot:	7000.00
X :	1560861.46	X :	1576609.47
Y :	10199728.63	Y :	10199978.92
LONG:	-89.16352709	LONG:	-89.11466242
LAT :	28.10678008	LAT :	28.10754803

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1. Only three points are needed to determine world coordinates, two on one line and any other line/trace for the third point.
2. Internal Y coordinates refer to shots.
3. Inline Spacing (Distance between Crosslines): 43.75 US_SURVEY_FEET.
4. Cross-line Spacing (Distance between Inlines): 87.50 US_SURVEY_FEET.
5. Record Length: 2.00 MS.
6. Sample Rate: 2.00 MS.
7. Azimuth between the primary direction and due north: -0.91 DEGREES.
8. Shots inc. by 5